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**FOR RELEASE: TUESDAY A.M.**  
**APRIL 26, 1966**

RELEASE NO: 66-89

**PROJECT: LIFTING BODIES FLIGHT PROGRAM**  
(scheduled for launch in  
April 1966)

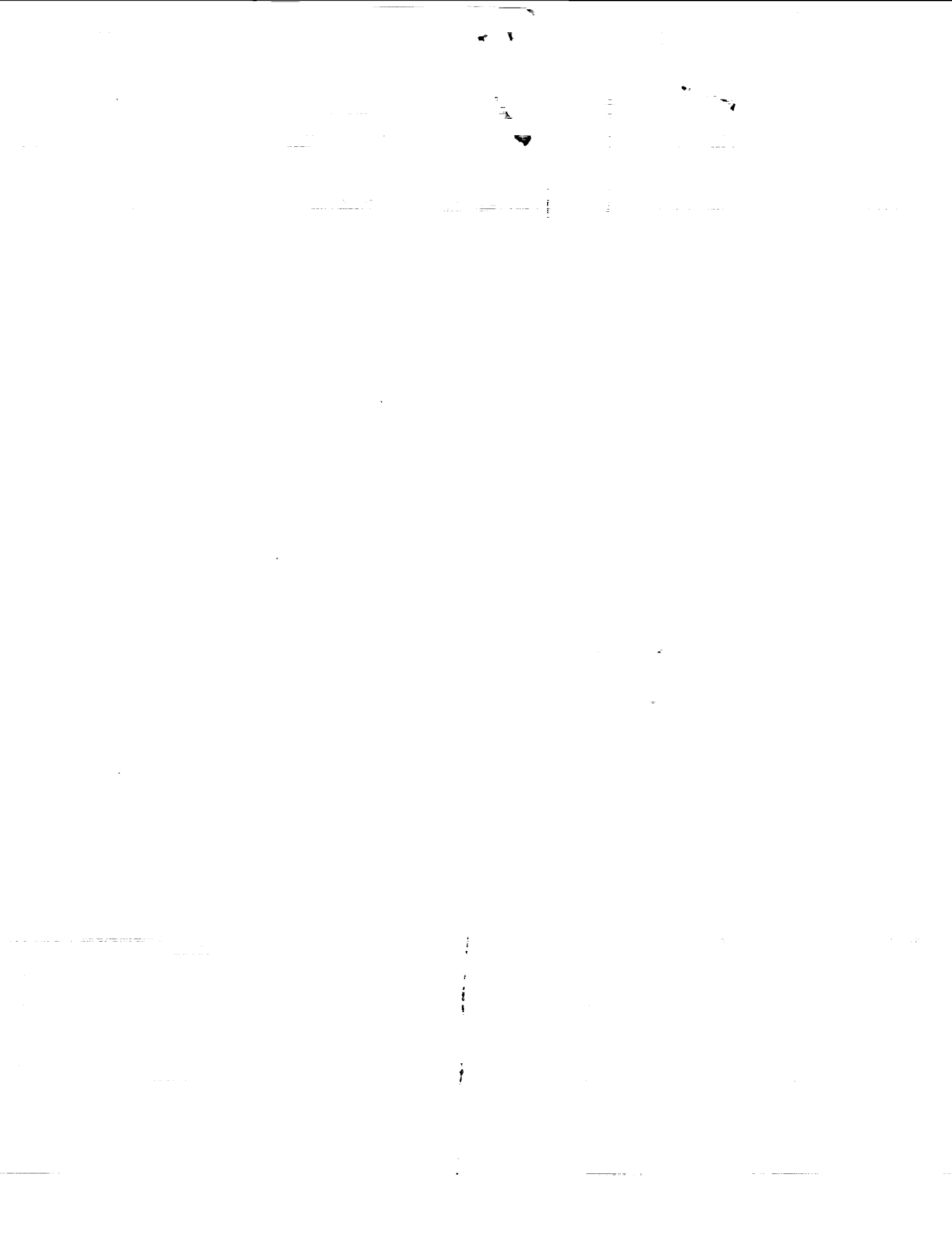
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FIRST GLIDE FLIGHT  
OF HEAVY LIFTING BODY  
PLANNED SOON

The first glide flight of a two and one-half ton lifting body will be conducted by the National Aeronautics and Space Administration in the near future.

At the controls will be Milton O. Thompson, chief lifting body research pilot for NASA's Flight Research Center, Edwards, Cal.

The M2-F2 lifting body will be launched from the wing of a B-52 bomber aircraft at 45,000 feet altitude at about 450 miles per hour. The wingless body will fly on the aerodynamic lift obtained by its rounded half-cone shape as Thompson glides to a landing on Rogers Dry Lake.

The lifting body concept is being investigated in flight by NASA's Office of Advanced Research and Technology to help establish the technological base for design of future manned re-entry vehicles. The lifting body potential lies in greater aerodynamic lift -- higher lift-drag ratios than manned re-entry spacecraft in present use.

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An extensive flight research program is planned with initial emphasis on the final approach and landing.

On the first free flight of the M2-F2, the B-52 will make a 20-minute circular climb to 45,000 feet, remaining in glide distance of the lake bed, as it approaches the launch area while Thompson performs pre-launch checks, including test bursts of the four small rockets that can be used in final approach to help cushion the landing.

Thompson will launch himself in a straight-ahead glide and then turn left 90 degrees. This will be followed by a straight leg during which Thompson will make a practice landing flareout at about 25,000 feet.

He will then make another 90-degree left turn to the final landing approach. As he reaches approximately 1,200 feet altitude, he will begin the flare maneuver to slow his rate of descent from about 250 feet-per-second to less than 10-feet-per-second, the planned vertical velocity at touchdown. During this maneuver, he will decrease his horizontal velocity from 350 mph during the descent to about 170 mph at touchdown.

After the flare maneuver, and the steep rate of descent is arrested, he will extend the landing gear. If needed, four hydrogen peroxide rockets, mounted in the rear of the vehicle, can be used to provide up to 1,600 pounds of thrust. This thrust would be used to give the pilot additional time to make the landing.

The entire free flight should take about four minutes.

The purpose of the flight is to perform a complete design and systems checkout of the vehicle and evaluate vehicle stability and control. Wherever possible, back-up systems have been provided. In the event of possible failures, the M2-F2 is equipped with a rocket-powered ejection seat that is designed to separate the pilot from the vehicle at any speed or altitude, even when attached to the B-52.

The heavyweight lifting body, designated the M2-F2, is a heavier version of the plywood M2-F1 lifting body that was first flown (by Thompson) in August 1963. The M2-F1 was towed to an altitude of approximately 12,000 feet by another aircraft where it was released for free flight. Almost 100 air-tows of the M2-F1 have been made to date.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

### LIFTING BODY BACKGROUND

The original idea of lifting bodies was conceived in 1957 by Dr. Alfred J. Eggers, Jr., Assistant Director for Research and Development Analysis and Planning at Ames Research Center. He is now NASA Deputy Associate Administrator for Advanced Research and Technology.

The concept is based on attaining aerodynamic stability and lift from a body alone, eliminating the need for wings. Without wings, a higher ratio of useful volume-to-surface area is obtained. Lift results from more air pressure on the bottom of the body than on the top.

Present U.S. manned space flight missions use a modified ballistic-type re-entry and parachute recovery to a water landing. These spacecraft are designed to re-enter ballistically in order to dissipate the energy attained from orbital flight.

However, in the future, spacecraft with improved maneuverability and flexibility of re-entry and recovery may be required. A lifting body is designed to use orbital energy and aerodynamic lift for in-flight maneuvering and a glide landing.

Theoretical analyses and experimental wind tunnel development of lifting bodies centered on a number of half-cone shapes to determine which ones would provide lift-drag ratios high enough for hypersonic (above 3,300 mph) maneuverability and the potential for horizontal landing.

To reduce heating during atmosphere entry, the nose of the cone was blunted, a concept developed earlier for ballistic missiles and spacecraft. Fins were installed to provide stability and control surfaces were added for maneuverability. A canopy allows the pilot visibility for atmospheric maneuvering and landing.

A seemingly endless repetition of conceiving, testing, changing, testing, modifying, and testing was required before experimental results could be said to satisfy the desired, theory-based requirements.

The first manned lifting body vehicle to fly was a modified plywood and tubular steel version called the M2-F1. It was towed aloft by a C-47 airplane and released to glide to a landing. About 100 free flights have been made.

This low-cost, minimum effort program was conducted at NASA's Flight Research Center under the guidance of Paul F. Bickle, FRC Director.

Flights with the lightweight experimental version confirmed other studies that indicated the concept could generate enough lift and control to permit a pilot to maneuver and select his landing site from a large area.

Based on the results of this program, a contract was awarded in mid-1964 to the Norair Division of the Northrop Corp., for the construction of two heavyweight lifting bodies: M2-F2 and the HL-10, a concept originated and tested at the NASA Langley Research Center, Hampton, Va.

The M2-F2 was delivered to the NASA Flight Research Center in June 1965, and the HL-10 in January 1966. Total NASA expenditure for construction of the two vehicles was \$1.8 million.

In addition to providing a backup flight vehicle, the decision to build two vehicles allows the study of two different shapes that show promise for future use. After delivery, instrumentation was installed on both vehicles for testing in the full-scale wind tunnel at NASA's Ames Research Center. Both the M2-F2 and HL-10 underwent wind tunnel testing at Ames before being returned to FRC for minor modifications.



NASA wind tunnel and other theoretical studies indicate that a lifting body could generate enough lift and control to permit a pilot returning from space flight to select his landing site from a large area. How large a distance depends on when during the re-entry phase the particular landing site is selected. For example, an area the size of the southern half of the United States would be available initially if the selection was made prior to beginning re-entry and would then diminish as velocity and altitude decreased. This same lift capability also would allow the pilot to make a horizontal landing on land in much the same manner as the X-15 rocket airplane is landed.

Continuing research has identified a number of other advantages for potential applications of lifting bodies. The fact that they have no wings eliminates many possible structural and heating problems. The body shape offers an attractive amount of internal volume with a small surface area. The blunt shapes also lend themselves to use of ablative material to dissipate heat and their maneuverability allows lower decelerations and temperatures under re-entry conditions.

Lifting body vehicles are considered potentially useful for a variety of future missions in space; for example, spacecraft inspection, repair and reconnaissance; logistic and re-supply of advanced space stations; search and rescue; manned

interplanetary missions, and as an upper stage of a recoverable launch vehicle.

Although no mission or research plan has been determined by NASA for the design or construction of an actual space flight vehicle, the research must be performed well in advance to permit freedom of choice if such a program becomes necessary.

Thus far, all U.S. manned spacecraft have been landed in the oceans, but future mission planners will need the option of landing at ground sites and will want a spacecraft able to fly long distances inside the atmosphere before maneuvering to a safe touchdown under a pilot's control.

#### FLIGHT RESEARCH PROGRAM

Flight scheduling depends on a number of factors, including weather, vehicle and system checkouts before and after flights, possible vehicle and system modifications between flights, and availability of the launch aircraft. The two launch aircraft are used in the X-15 research program and are heavily involved in air-launch of the three rocket-powered vehicles in that program.

As with the X-15 research program, a terminal pre-launch checkout and countdown is conducted while the lifting body is airborne under the wing of the B-52. Any weather or technical problems that arise during this phase could cause cancellation of the glide flight for that day. Significant last-minute changes in ground level winds, for instance, might result in a no-go decision.

The flight test portion of NASA's lifting body program employs two different configurations: M2-F2 and HL-10. F2 refers to the second modification of the basic M-2 shape, with M referring to manned. HL refers to horizontal landing and 10 means it is the 10th concept of its type to be investigated by the Langley Research Center.

The M2-F2 is a flat-topped, rounded bottom, half-conical design with two vertical fins at the rear of the vehicle.

The half-conical HL-10 has a flat bottom and a round top, three vertical fins at the rear and is 5-1/2 feet wider than the M2 across the tail.

Both vehicles are 22 feet long, but the HL-10 stands about two feet higher from the ground to the top of the center fin. There are also significant differences in the controls of the two vehicles.

Both are carried beneath the wing of the B-52 at speeds of about Mach 0.6 (450 mph) at about 45,000 feet altitude. Both also will be able to accomodate rocket engines for extra propulsion at a later date.

Duration of the glide flights, from launch to landing, will be about four minutes. Speed at flare-out altitude (1,200 feet) is about 330 mph with the landing speed estimated at 160 to 240 mph.

Prior to the first scheduled free-flight of the M2-F2, captive flights and ground runs were made. The first captive flight occured on March 23, 1966. Two high-speed taxi tests were made with the M2-F2 mated to the B-52 to test the structural compatibility of the B-52 pylon adapter. Another series of taxi tests with the M2-F2, using its landing rockets for power, were made to demonstrate the steering and brake effectiveness of the landing gear. A complete systems checkout was made in flight with the B-52 and the manned M2-F2.

The heavyweight M2-F2 will be flown initially with its internal water ballast tanks empty. Main purpose is pilot familiarization and landing evaluation. On later flights, the pilot will be given specific tasks for research.

Eventually, a gradual increase of ballast will be made flight-by-flight to determine the effects of increased loading. One objective of the flight research program is to attain maximum ratios of loading to surface area. Full weight will correspond to that of present manned space flight re-entry capsules.

Provisions have been made for the possible installation of an XLR-11 rocket engine in the M2-F2. If accomplished, this will allow extension of the flight research program to altitudes up to 80,000 feet and at speeds just under twice the speed of sound. These flight conditions would approximate those encountered in the terminal phase of a returning spacecraft.

The flight testing program of the HL-10 will closely approximate that of the M2-F2.

NASA's Milton Thompson is chief pilot of the flight programs for both the M2-F2 and the HL-10. He has piloted the X-15, the Paraglider Research Vehicle, and the plywood M2-F1. Another NASA civilian pilot, Bruce Peterson, and Capt. Jerauld R. Gentry, Air Force Flight Test Center, Edwards AFB, are assigned to flight responsibilities under the direction of Thompson.

M2-F2 FACT SHEET

DESCRIPTION:

The M2-F2 is a manned research vehicle representative of the wingless lifting body class of vehicles. They are under study by NASA for such possible future use as returnable, reusable spacecraft capable of maneuvering during re-entry and performing, under pilot control, a horizontal landing at selected land sites. The vehicles derive aerodynamic lift and stability from their shape alone, eliminating the need for wings.

MISSION:

The M2-F2 is being used to study the aerodynamic problems associated with flight in the Earth's atmosphere. Special emphasis is placed on the approach and landing maneuver. Other areas of interest include stability, control and handling qualities.

CONFIGURATION:

The vehicle is half-conical in shape with no wings, two vertical fins, and a rounded, blunt nose.

DIMENSIONS:

Length - 22 feet 2 inches

Width - 9 feet 7 inches

Height - 8 feet 10 inches (ground to top of fins)

Weight - 5,000 lbs.

Water ballast tanks can increase  
weight up to 9,000 lbs.

CONTROLS:

The control system is powered by two independent irreversible hydraulic subsystems (3,000 pounds per square inch) operating simultaneously. A stability augmentation system electrically assists in aerodynamic damping of motions. A ram air turbine (RAT) provides emergency pump power for the hydraulic systems in the event of an electrical failure. Two vertical rudders are used for yaw control and to act as speed brakes. One full-span flap on lower rear of fuselage controls pitch. A pair of split horizontal flaps on upper rear of fuselage operate in two ways: Moving differentially, they control roll and moving in synchronization, they control pitch and trim.

POWER:

Six silver-zinc batteries provide electrical power to operate the control system, flight instruments, radios, landing rockets, stability augmentation system, defrosters and cockpit heat.

LANDING GEAR:

Main landing gear is modified T-38 gear that retracts manually. Upon pilot activation, nitrogen pressure opens the landing gear doors and extends the gear. The nose gear is a dual wheel modified T-39 gear that also retracts manually and is extended by nitrogen pressure.

BALLAST TANKS:

Two cylindrical tanks capable of holding a total of 4,000 pounds of water are installed inside the M2. The pressurized tanks can jettison water in 30 seconds. Tanks could be used to carry fuel if an engine is installed. On initial flights hydrogen-peroxide tanks will replace these to provide extra fuel for the landing rockets.

LANDING ROCKETS:

Four throttleable hydrogen-peroxide rockets provide up to 400 pounds of thrust each to assist flare-out on the landing approach.

EJECTION  
EQUIPMENT:

A modified F-106 ejection system made by Weber Aircraft Co. provides ejection capability. Ejection at zero altitude or while attached to the B-52 is possible.



FLIGHT:

Powerless, the M2-F2 is carried by a B-52 to a launch altitude of 45,000 feet. At about 450 miles per hour, the M2-F2 is released for glide flight to a landing. Descent speeds may be varied from about 180 to 400 mph. A rocket engine may be installed at a later time that would extend the flight capability.

MANUFACTURER:

Norair Division of the Northrop Corp., Hawthorne, Calif.

COMPARISON OF M2-F2 AND HL-10

	<u>M2-F2</u>	<u>HL-10</u>
LENGTH	22 feet, 2 inches (nose tip to tips of backswept tail fins)	Same
WIDTH	9 feet, 7 inches (extreme rear of vehicle)	15 feet, 1 inch (including tips of fins)
HEIGHT	8 feet, 10 inches (ground to top of fins)	11 feet, 5 inches (ground to top of center fin)
MINIMUM WEIGHT	5,000 pounds (with water ballast test tanks empty)	5,265 pounds (with water ballast test tanks empty)
MAXIMUM WEIGHT	9,000 pounds (water ballast tanks full for tests)	Same

CONTROLS

A rudder on the outer face of each fin for yaw control, with a variable inter-connect to the upper flaps to aid in roll control. Upper flaps for roll control and pitch trim. One full-span pitch flap on lower surface of boattail. All surfaces are used in the three-axis, stabilizer-augmenter system.

A thick "elevon" between each outer fin and the center fin for pitch and roll control. A split rudder on the center fin for yaw and speed brake control. All surfaces are used in the three-axis, stabilizer-augmenter system. Each elevon has a flap on the upper surface, each outer fin has two trailing edge surfaces, and the two rudder surfaces can be controlled to vary the base drag.

LAUNCH  
STRUCTURE

Special 22-foot-long Northrop Norair adapter attached to existing X-15 launch pylon on wing of B-52 aircraft. Adapter is a combination box-beam and truss structure with aluminum fairing enclosing tanks for M2-F2/HL-10 cabin pressurization and pilot oxygen during captive mode.

Same

LIFTING BODY RESEARCH TEAM

NASA Headquarters  
Office of Advanced Research and Technology

Milton B. Ames, Director, Space Vehicle Research and Technology

E. O. Pearson, Deputy Director, Space Vehicle Research and  
Technology

Clotaire Wood, Chief, Vehicle Technology Flight Experiments

Fred J. DeMeritte, Manager, Lifting Body Program

Flight Research Center

Paul F. Bikle, FRC Director

John McTigue, Lifting Body Program Manager for FRC

Robert Dale Reed, Project Research Engineer

Meryl D. DeGeer, Operations Project Engineer

Milton O. Thompson, Chief Project Pilot, Lifting Body Program

Northrop Corp.

Ralph Hakes, Director, M2-F2/HL-10 Project

Air Force Flight Test Center

Brig. Gen. Hugh B. Manson, Commander

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BIOGRAPHICAL SKETCH

Milton O. Thompson

Milton O. Thompson, a civilian research pilot-engineer for NASA's Flight Research Center, is the chief pilot on the M-2 and HL-10 Lifting Body flight test program.

He is assigned also as one of the project pilots on the rocket-powered X-15. He has flown the research aircraft at speeds in excess of 3,700 miles per hour and to an altitude of 214,000 feet (40 miles high).

Joining NASA in 1956, Thompson made the first manned lifting body flight in a lightweight M2-F1 in August 1963. He was the only civilian selected as a pilot for the X-20 Dyna Soar project.

Born in Crookston, Minn., May 4, 1926, Thompson served as a naval aviator in World War II with duty in China and Japan. He was graduated by the University of Washington in 1953 with a bachelor of science degree in engineering. Following graduation he became a flight test engineer with the Boeing Co., Seattle.

The author of several technical papers, Thompson is a member of the Society of Experimental Test Pilots.

His mother, Mrs. Alma Thompson lives in Pasadena, Cal.

Thompson and his wife, the former Theresa Beytebiere of Seattle, with their five children reside in Lancaster, Cal.

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